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Aplication of Durable Concrete in Structural Civil Constructions of Albania

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ABSTRACT

Today in Durres, even wider, buildings constructed with durable concrete are very few in now days. Geological studies show that the soil in foundation has low retaining capacity for this city due to high friction angle. This is also one of the other factors that Seismicity of the area is very high, up to level 9 ball of Rihter. The purpose of this article is the production of durable concrete with low permeability of water. The project is constructed in our country and in particular in Durres where groundwater level is higher and the use of space efficiently needs to build parking with underground floor.

KEYWORDS: Concrete durability, foundation, permeability of foundation concrete, seismology of Durres city.

1 INTRODUCTION

Durability of foundation concrete structures is a widespread and universal problem. We can build underground floors, in the presence of groundwater, without the need for additional isolation works. Repairing can be made even within the object, but in the case of this isolation is almost impossible to do it. The aim is that in any case should have limited penetration of the devastating effects of water that are present in the environment of exposure and hence reduce the number, intensity and importance of maintenance interventions. To obtain the durable concrete witch meet our project specifications, the concrete should have a coefficient of permeability K , smaller or equal to 1.10 -11 m/ s or a resistance to water penetration under ISO 7031-1994 standard specifications, or otherwise rely on standard EN 206-1 , permeability should be up to 20 to 50 mm.

1.1 Geotechnical study of the project

The maximum expected magnitude for Durres city is Mmax=6.5-7.0. Durres City is included within the area of isoline of mean return period of Tp=200-250 years, for shakings with intensity Io=VIII (MSK-64) or PGA=0.2g. It means that shakings with intensity VIII or PGA=0.2 g is not going to be exceeded every 25 years with a probability of 90%. Concerning shakings with intensity IX degree mean return period will be about 1000 years.

1.2 Seismic risk of Durres city

Based on studies carried out for seismic hazard assessment at local it was observed: For a PGA=0.2g value on bedrock, .the highest 2-D response (PGA=11m/s/s at Ts=0.5s) was observed on the deepest part of Durres graben, where the thickness of poor sediments is about 130m. Comparing these data with 1-D solutions it can be seen that Sa spectra for 1-D solution on this part of the graben are characterized by much smaller peak amplitudes (PGA=1.5-2.0m/s/s) but for a wider range of periods. The shape of 1-D Sa spectra is almost flat. This can be explained by the degradation of G moduli and increase of strains for thick models. On the basis of analysis results is discussed seismic risk calculation made for construction site (Frankel et al.1995). The calculations were carried out for PGA values and periods at 0.1 seconds, 0.2, 0.3, 0.5, 1 and 2, the four repetition periods 95; 475, 975, and 2475 years, which was corresponding probabilities of exceeding 10% in 10 years, 10%, 5% and 2% in 50 years, respectively.

Amplification with strong surface model for earthquakes reached DYRR EW type and DAF Amax = 0.43g 1:48. At maximum acceleration 5.0M average depth is between A max = 0.31g, DAF = 1.069. Average maximum acceleration on the surface of the soil is between Amax = 0.38g and DAF = 1.31.

Table 1.2.1 Maximal values of spectral and horizontal accelerating

Period	**Spectral acceleration**			
Sec	**RP = 95 Years**	**RP = 475 Years**	**RP = 975 Years**	**RP = 2475 Years**
PGA	0.189	0.286	0.333	0.404
0.10	0.271	0.459	0.563	0.720
0.20	0.358	0.593	0.722	0.916
0.30	0.316	0.528	0.653	0.832
0.50	0.203	0.352	0.440	0.578
1.00	0.083	0.151	0.193	0.261
2.00	0.044	0.080	0.102	0.138

Table 1.2.2 PGA (Amax) values and DAF in construction site according TIR-NS, LSK EW, AL-NS DURR-EW and DURR-NS.

H (m)	**DURR-EW**		**DURR-NS**		**AL-NS**		**LSK-EW**		**TIR-NS**		**Amax (mes)**	**DAF (mes)**
	A max	**DAF**	**A max**	**DAF**	**A max**	**DAF**	**A max**	**DAF**	**A max**	**DAF**		
0	0.43	1.48	0.42	1.45	0.35	1.21	0.38	1.31	0.32	1.10	0.38	1.31
4.0	0.36	1.24	0.36	1.24	0.30	1.03	0.37	1.28	0.29	1.00	0.34	1.17
5.0	0.32	1.10	0.35	1.21	0.28	0.97	0.36	1.24	0.25	0.86	0.31	1.07
10.0	0.26	0.90	0.29	1.00	0.25	0.86	0.31	1.07	0.29	1.00	0.28	0.97
12.0	0.22	0.76	0.22	0.76	0.25	0.86	0.23	0.79	0.27	0.93	0.24	0.83
15.0	0.23	0.79	0.20	0.69	0.26	0.90	0.25	0.86	0.26	0.90	0.24	0.83
28.0	0.29	1.00	0.30	1.03	0.27	0.93	0.31	1.07	0.30	1.03	0.29	1.00
66.0	0.29	1.00	0.29	1.00	0.29	1.00	0.29	1.00	0.29	1.00	0.29	1.00

1.3 Hydrological study of construction site

Results of the study showed that hydro-geological groundwater level is up to 0.8-1.5m from the ground system. Also the content of groundwater is aggressive, containing ph = 7.3 (according to the attached analysis), the amount of chloride Cl is 26.1 g/ l; sulphates SO4 = 6.21g/ l; dry content 7.85 g/ l = 7850 mg / l measured by the standard EN 1008. Standard limits for aggressive environmental conditions, for soils and underground water within the temperatures 5-250C. The highest value determines the class.

Table 1.3.1 Standard limits for aggressive environmental conditions

Chemical characteristics	Test method	XA1	Parameter of water in site
SO_4^{2-} (mg/l)	EN 196-2	$\geq 200\ and\ \leq 600$	**621**
pH	ISO 4316	$\leq 6.5\ and\ \geq 5.5$	**7.3**
CO_2 (mg/l)	prEN 13577	$> 15\ and\ \leq 40$	-
NH^{4+} (mg/l)	ISO 7150-1 ISO 7150-2	$> 15\ and\ \leq 30$	-
MG^{2+}(mg/l)	ISO 7980	$\geq 300\ and\ \leq 1000$	-
Soil			
SO_4^{2-} (mg/kg)	EN 196-2	$\geq 2000\ and\ \leq 3000$	-
Acidity (ml/kg)	DIN 4030-2	-	-

** (-) not measured*

1.4 Engineering-geological conditions of construction

Based on field observations, lithological composition of the construction site, evidence INSITU and physic-mechanical characteristics of soils and rocks that our construction site meets studies shows that only layer 3 and 4 with the given limit standard specification are suitable to construct and maintain bearing loads for foundation constructions:

Layer No. 3 Represented by small grain sand and gray silt impregnated with water and moderately compressed. Geological composition is given in the table below:

Table 1.4.1 Soil characteristics for layer no.3 and 4

Properties	Specifications/Index	Analysis results for layer no.3	Analysis results for layer no.4
Clay content	<0.00 2mm	8.9%	18.60%
Sand content	>0.05 mm	19.60%	37.80%
Silt content	0.002-0.05 mm	71.50%	43.60%
Specific density	ρ	2.69T/m^3	2.71T/m^3
Bulk density	Δ	1.98 T/m^3	1.5 T/m^3
Porosity coefficient	ε	0.7	0.78
Compression modulus	E	110kg/cm^2	65kg/cm^2
Friction angle	φ	320	240
Compressive load allowed	σ	1.8kg/cm^2	0.10 kg/cm^2

2 MATERIALS AND METHODOLOGY

2.1 Materials

2.1.1 Cement

The details of the experimental program have been reported in this study. Concrete ingredients produced by the Albanian standard S SH EN 206-1:2003, with resistance class C25/30, were taken in Fushe Kruja from Vega concrete production site. The concrete is produced in SAG concrete plant. Composition of Portland cement, CEM I 42.5 R, from ANTEA, type cement conforming EN 197-1 was used in this study.

2.1.2 Aggregates

Coarse and fine aggregates obtained from Milot and Kruja quarry units have been used for this study. Maximum size of coarse aggregate used is 25 mm and specific gravity of ranging from 2.6 - 2.7 kg/m3 based on standard S SH 509:1987; bulk density 1484 kg/m3 and fine modulus 6.07. For fine aggregates maximum size used is 5 mm and specific gravity of ranging from 2.687 kg/m3 based on standard S SH 509:1987; and fine modulus 2.74.

2.1.3 Water

Potable tap water available production site was used for mixing and curing of concrete. The water is filtrate based on standard 2751:1987.

Table 2.1.3.1 Chemical analysis of water used in mix design

No.	Characteristics	Units	Test results	Standard limit EN 1008
1	Water resource		Well water	-
2	Colour		Transparent	-
3	Odour		None	-
4	Water density @ 190 C	kg/ l	1.0082	0.9982
5	Total hardness (CaCO3)	mg/l	2.91	-
6	Total dissolved solids at 180 ºC	mg/l	3.82	≤4
7	pH value		7.61	≥4
8	Chloride content Cl-	mg/l	1241	≤ 1000
9	Sulphate content SO4-	mg/l	4996	≤ 2000
10	Salts content	mg/l	0.02	≤ 100

2.1.4 Concrete admixtures

Additives used in this project are; Chryso-Fluid Premia 180(superplasticizer) and Penetron Admix (uperplasticizer) and in quantities 3 l/m3 concrete. Additives were used to produce concrete class C25/30 MPa and the result was decreasing the amount of water. The effect of using the lowest amount of water is increasing the durability and resistance of concrete.

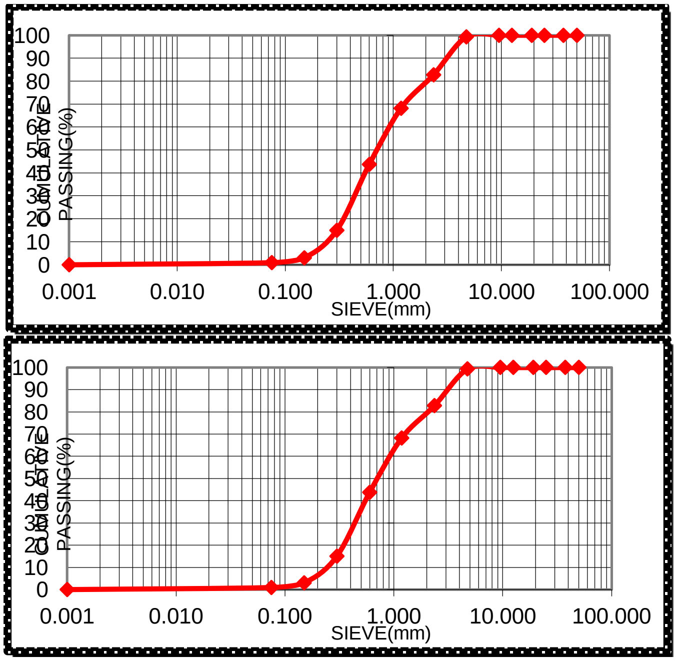

Figure 2.1.4.1: a) Coarse and b) fine aggregates PSD analysis.

2.2 Methodology

2.2.1. Durable concrete mix design

Mix design is a process of selecting suitable ingredients for concrete and determining their proportions which would produce, as economically as possible, a concrete that satisfies the Orion project requirements.

All mix designs data for durable concrete used in our project are represented in Table 2.2.1.1. In present study durable concrete class C30/45 was produced with river raw material. All mix designs are formulated based on specifications of EN 206-1 standard.

Table 2.2.1.1 Mix design of concrete

<table>
<tr><td rowspan="2">Class</td><td rowspan="2">C25/30</td><td>Slump</td><td>S4</td><td rowspan="2">Exposure class</td><td>XS_3</td><td rowspan="2">D_{max}</td><td rowspan="2">20</td></tr>
<tr><td>w/c ratio</td><td>0,40</td><td>19^0c</td></tr>
<tr><td colspan="2">Standard applied</td><td colspan="3">S SH EN 206-1:2003</td><td colspan="3">31.10.2013</td></tr>
<tr><td colspan="2"></td><td colspan="3">Concrete for underground construction</td><td colspan="3"></td></tr>
<tr><td>No.</td><td colspan="4">Ingredients</td><td>Units/m^3</td><td colspan="2">Quantity</td></tr>
<tr><td>1</td><td colspan="4">Natural river sand 0-04 mm</td><td>kg</td><td colspan="2">850</td></tr>
<tr><td>2</td><td colspan="4">Crashed sand 0-04 mm</td><td>kg</td><td colspan="2">152</td></tr>
<tr><td>3</td><td colspan="4">Crashed river gravel 5-10 mm</td><td>kg</td><td colspan="2">285</td></tr>
<tr><td>4</td><td colspan="4">Crashed river gravel 10-25mm</td><td>kg</td><td colspan="2">650</td></tr>
<tr><td>5</td><td colspan="4">Cement CEM I 45.2 R/A-LL</td><td>kg</td><td colspan="2">350</td></tr>
<tr><td>6</td><td colspan="4">Additive
Chryso-Fluid Premia 180 (superplasticizer)
Reduction. 15%;
Dosage 0.8 lit/100 kg cement)</td><td>lit/m^3</td><td colspan="2">3</td></tr>
</table>

	Additive PENETRON ADMIX (uperplasticizer) Reduction. 15%; Dosage 0.8 lit/100 kg cement)	lit/m^3	3
7	Well water	lit	139
8	w/c ratio	**-**	**0.4**

The compressive strength of concrete is considered as the index of its quality. Therefore the mix designs are generally carried out for a particular compressive strength of concrete with adequate workability so that the fresh concrete can be properly mixed, placed and compacted.

After 28 days period of curing, the specimens were taken out of the curing tank and there were tested besides measuring the fresh properties (workability, air content and concrete temperature); following tests such as permeability of concrete cubes and chlorides contents are measured.

Figure 2.2.1.1: a); b);c);d) Concrete production site

3 RESULTS & TABLES

3.1 Compressive strength of concrete cubes in Orion construction site

Compressive strength, of mixes was determined at various ages as per EN 12390-3:1999 and EN 12390-5:1999 are given in table 3.1. Cube Compressive strength at the age 28 days. After casting the specimens were covered with sheets to minimize the moisture loss from them. Specimens were demoulded after 24-hours and then cured in water at approximately room temperature till testing. Compressive strength tests for cubes were carried out at 28 days. All the specimens were tested in an automated compressive strength machine shown in Figure 3.1:

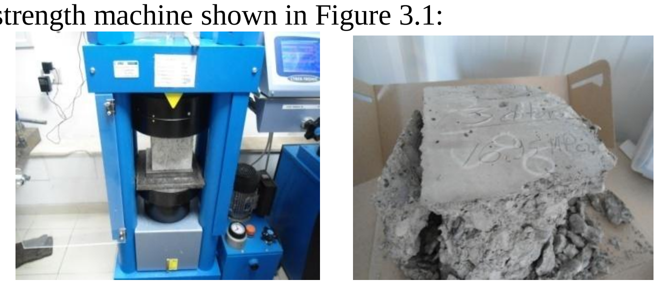

Figure 3.1.1: Compressive strength machine

Table 3.1.1 Results for compressive strength test of concrete cubes taken from ORION object.

No.	Report number	Casting date [dd/mm/yy]	Testing date [dd/mm/yy]	Curing age [Days]	Density [kg/m3]	C.S [MPa]
1	5416/13	18.11.2013	16.12.2013	28	2430	32.78
2	5414/13	20.11.2013	18.12.2013	28	2444	33.66
3	5412/13	25.11.2013	24.12.2013	28	2490	34.69
4	5411/13	25.11.2013	24.12.2013	28	2467	37.90
5	4769/13	15.11.2013	13.12.2013	28	2405	30.47
6	4768/13	15.11.2013	13.12.2013	28	2415	33.34
7	4767/13	29.11.2013	06.12.2013	28	2455	33.19
8	4764/13	12.11.2013	10.12.2013	28	2449	32.93
9	4762/13	05.11.2013	03.12.2013	28	2402	38.85
10	4552/13	31.10.2013	28.11.2013	28	2443	35.91

3.2 Durability of concrete

The durability of concrete depends largely on the movement of water enters and moves through it. Permeability is a measure of flow of water under pressure in a saturated porous medium while Sorptivity is materials ability to absorb and transmit water through it by capillary suction. The porous structure of concrete is intimately related with its permeability. A low water/cement ratio results in concrete structures which are less permeable because they are characterized by having small pores which are not interconnected. The water penetration under pressure test is a standard test procedure (EN 12390-8).

Figure 3.2.1: Images of water penetration and chloride content test

Table 3.2.1: Water depth penetration and chloride content for concrete cubes tested.

No.	Concrete class	Depth of water penetration [mm] EN 12390-8	Concrete chloride content [%] EN 196-2
1	C 25/30	22.4	0.027
2	C 25/30	20.8	0.015
3	C 25/30	23.6	0.033
4	C 25/30	22.4	0.012
5	C 25/30	24.6	0.036
6	C 25/30	20.4	0.015
7	C 25/30	20.3	0.069

8	C 25/30	20.5	0.012
9	C 25/30	20.5	0.011
10	C 25/30	20.6	0.023

The depth of water penetration test made on concrete cubes revealed in creation of protective layer structures for reinforced concrete. Specifically in our project, this protective cover on plate will be carried out on 7cm and 3cm underground floor walls. Here are some views of realization of underground floor of this building.

Figure. 3.2.1: The foundation of the project.

4 CONCLUSIONS

Seismologic project data showed that layer 3 and 4 are adaptable for making foundation of the project.

Based on geological project information, durable concrete for deep underground basements is an important component of new urban building construction. This is often because parking in most large cities is generally inadequate and often serviced by aging, outdated, and deteriorated above-grade parking structures that do not fit the surrounding architecture and occupy valuable aboveground space.

So in this thesis , I wanted to say that it is very importante to produce and to use the durable concrete, in our country, in the structure of the ground floors when we have a hight level of underground water. This is reached by decreasing the permeability through the decreasing of water/cement ratio and increasing the protective cover of reinforcement concrete according to the level of the penetration of water and chloride test.

Using durable concrete we have some beniftis such are:

1. Using durable concrete is economic and social benefit product
2. Increase the lifetime of the concrete structural
3. Better utilization of urban spaces
4. Increase the number of floors underground.
5. We have no maintenance costs or use for calculating the period of stability.
6. Degradation of deferred from the standard 50 years today, in 80-100 years.
7. Used in normal conditions and all underground facilities for any activity, since the presence of moisture is eliminated.
8. Albanian goes towards housing facilities Contemporary with European Standards. The corresponding entry in the EU.

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